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# DATA SHEET

MPEG Multichannel

# SAA2503
MPEG2 audio decoder

Objective specification
File under Integrated Circuits, IC01

1997 Jul 02

Philips
Semiconductors

PHILIPS

# MPEG2 audio decoder SAA2503

## FEATURES

- Single-chip MPEG2 multichannel audio decoder
- Decodes MPEG high quality audio:
  - MPEG1 layer 2 (44.1 kHz)
  - MPEG2 multichannel layer 2 (48 kHz)
  - Supports pause frames
- Outputs 2 channels
  - Quasi surround down-mixing for Left and Right Dolby surround channel (Lt and Rt)
  - Stereo down-mixing for stereo reproduction
  - Stereo signal selection
  - Single channel down-mixing
- Karaoke modes
- Linear PCM modes:
  - Down-sampling from 96 to 48 kHz
  - Pass 48 kHz signals
- Bitstream input interface $I^2S$-bus (IEC 1937 formatted)
- IEC 958 output interface (IEC 1937 formatted)
- IEC 958 output simultaneously available while decoding MPEG2
- $I^2C$-bus control
- Output flags for direct control
- Stand-alone operation possible (self-booting)
- No external DRAM or SRAM required
- On-chip PLL for internal clock generation
- 13.5 or 27 MHz master clock
- 100 pins plastic LQFP package
- 5 V power supply.

## APPLICATIONS

This IC is mainly intended for use in Digital Versatile Disc (DVD) players. However it may also be used in any application that is able to accept an MPEG2 audio bitstreams such as:

- Set top boxes
- Multimedia PCs
- Digital television
- Next generation audio equipment.

## GENERAL DESCRIPTION

The SAA2503 incorporates all necessary functions, such as MPEG2 multichannel audio decoding plus down-mixing, MPEG1 layer 2 decoding, Linear PCM (LPCM) processing all producing high quality audio. Together with the serial audio interfaces and the IEC 958 transmitter this allows for the complete audio function of a DVD player in a single chip.

## ORDERING INFORMATION

| TYPE NUMBER | PACKAGE | | |
|---|---|---|---|
| | NAME | DESCRIPTION | VERSION |
| SAA2503HT | LQFP100 | plastic low profile quad flat package; 100 leads; body 14 x 14 x 1.4 mm | SOT407-1 |

## FUNCTIONAL I/O DIAGRAM

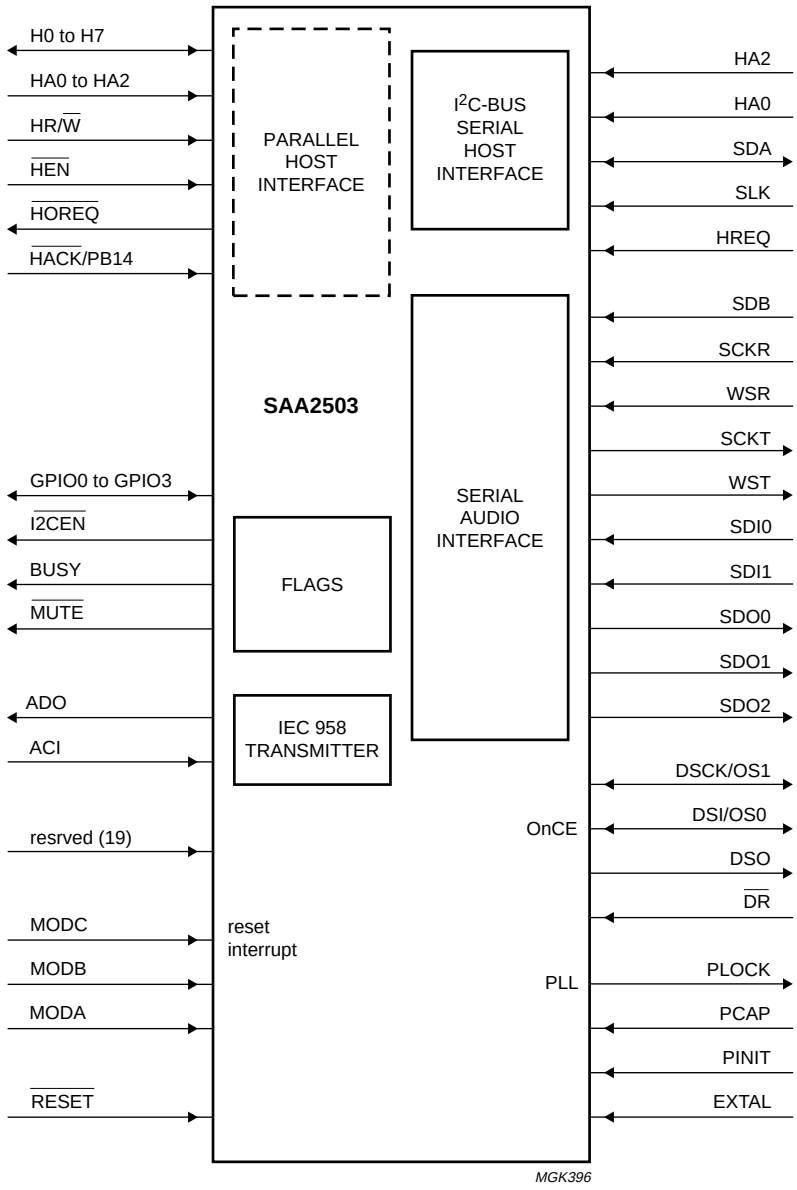



Fig.1 Functional I/O diagram.

**PINNING**

| SYMBOL | PIN | I/O | DESCRIPTION |
|---|---|---|---|
| n.c. | 1 | – | not connected |
| n.c. | 2 | – | not connected |
| GNDA1 | 3 | GND | ground 1 for some sections of internal logic |
| n.c. | 4 | – | not connected |
| n.c. | 5 | – | not connected |
| H7/PB7 | 6 | I/O | not used |
| H6/PB6 | 7 | I/O | not used |
| GNDH1 | 8 | GND | isolated ground 1 for the HI I/O drivers |
| HOA2/PB10 | 9 | I/O | not used |
| $V_{CCH1}$ | 10 | supply | isolated power supply 1 for some sections of the internal chip logic |
| HOA1/PB9 | 11 | I/O | not used |
| HR/$\overline{W}$/PB11 | 12 | I/O | not used |
| $\overline{HEN}$/PB12 | 13 | I/O | not used |
| $V_{CCQ1}$ | 14 | supply | isolated power supply 1 for the HI I/O drivers |
| GNDQ1 | 15 | GND | isolated ground 1 for the internal logic |
| $\overline{HACK}$/PB14 | 16 | I/O | not used |
| GNDH2 | 17 | GND | isolated ground 2 for the HI I/O drivers |
| HOA0/PB8 | 18 | I/O | not used |
| H5/PB5 | 19 | I/O | not used |
| $V_{CCH2}$ | 20 | supply | isolated power supply 2 for the HI I/O drivers |
| H4/PB4 | 21 | I/O | not used |
| H3/PB3 | 22 | I/O | not used |
| GNDH3 | 23 | GND | isolated ground 3 for the HI I/O drivers |
| H2/PB2 | 24 | I/O | not used |
| H1/PB1 | 25 | I/O | not used |
| H0/PB0 | 26 | I/O | not used |
| $\overline{HOREQ}$/PB13 | 27 | I/O | not used |
| GNDH4 | 28 | GND | isolated ground 4 for the HI I/O drivers |
| $V_{CCH3}$ | 29 | supply | isolated power supply 3 for the HI I/O drivers |
| ADO | 30 | O | digital audio data output |
| ACI | 31 | I | audio clock input |
| n.c. | 32 | – | not connected |
| n.c. | 33 | – | not connected |
| n.c. | 34 | – | not connected |
| PLOCK | 35 | O | HIGH when PLL is phase locked |
| $V_{CCQ2}$ | 36 | supply | isolated power supply 2 for some sections of the internal chip logic |
| GNDQ2 | 37 | GND | isolated ground 2 for the internal logic |
| PINIT | 38 | I | PLL enable/disable control |
| GNDP | 39 | GND | ground dedicated for the PLL |
| PCAP | 40 | I | PLL capacitor input |

| SYMBOL | PIN | I/O | DESCRIPTION |
|---|---|---|---|
| $V_{CCP}$ | 41 | supply | supply voltage for the Phase Locked Loop (PLL) |
| EXTAL | 42 | I | external clock/crystal Input |
| SCL | 43 | I | $I^2C$-bus serial clock |
| GNDS1 | 44 | GND | isolated ground 1 for the SHI I/O drivers |
| SDA | 45 | I/O | $I^2C$-bus data and acknowledge |
| $\overline{RESET}$ | 46 | I | hardware reset for the microcontroller |
| MODA | 47 | I | mode select A |
| MODB | 48 | I | mode select B |
| MODC | 49 | I | mode select C |
| $V_{CCS1}$ | 50 | supply | isolated power supply 1 for the SHI I/O drivers |
| HA0 | 51 | I/O | $I^2C$-bus slave address 0 |
| HA2 | 52 | I | $I^2C$-bus slave address 2 |
| $\overline{HREQ}$ | 53 | I | host request |
| GNDS2 | 54 | GND | isolated ground 2 for the SHI I/O drivers |
| SDO2 | 55 | O | not used |
| SDO1 | 56 | O | not used |
| SDO0 | 57 | O | serial data output 0 |
| $V_{CCS2}$ | 58 | supply | isolated power supply 2 for the SHI I/O drivers |
| SCKT | 59 | O | transmit serial clock |
| WST | 60 | O | transmit word select |
| SCKR | 61 | I | receive serial clock |
| GNDQ3 | 62 | GND | ground 3 dedicated for the PLL |
| $V_{CCQ3}$ | 63 | supply | isolated power supply 3 for some sections of the internal chip logic |
| GNDS3 | 64 | GND | isolated ground 3 for the SHI I/O drivers |
| WSR | 65 | I | receive word select |
| SDI1 | 66 | I | serial data input 1 |
| SDI0 | 67 | I | not used |
| DSO | 68 | O | not used |
| DSI/OS0 | 69 | O | not used |
| DSCK/OS1 | 70 | O | not used |
| n.c. | 71 | – | not connected |
| n.c. | 72 | – | not connected |
| n.c. | 73 | – | not connected |
| n.c. | 74 | – | not connected |
| $\overline{DR}$ | 75 | I | not used |
| SDB | 76 | I/O | general purpose I/O |
| $\overline{MUTE}$ | 77 | I/O | general purpose I/O |
| GNDD1 | 78 | GND | ground 1 for some sections of internal logic |
| BUSY | 79 | I/O | general purpose I/O |
| $\overline{I2CEN}$ | 80 | I/O | general purpose I/O |
| $V_{CCD1}$ | 81 | supply | isolated power supply 1 for some sections of the internal chip logic |

| SYMBOL | PIN | I/O | DESCRIPTION |
|---|---|---|---|
| GPIO3 | 82 | I/O | not used |
| GPIO2 | 83 | I/O | not used |
| GNDD2 | 84 | GND | ground 2 for some sections of internal logic |
| GPIO1 | 85 | I/O | not used |
| GPIO0 | 86 | I/O | not used |
| GNDQ4 | 87 | GND | ground 4 for some sections of internal logic |
| $V_{CCQ4}$ | 88 | supply | isolated power supply 4 for some sections of the internal chip logic |
| n.c. | 89 | – | not connected |
| n.c. | 90 | – | not connected |
| GNDA2 | 91 | GND | ground 2 for some sections of internal logic |
| n.c. | 92 | – | not connected |
| $V_{CCA1}$ | 93 | supply | isolated power supply 1 for some sections of the internal chip logic |
| n.c. | 94 | – | not connected |
| n.c. | 95 | – | not connected |
| GNDA3 | 96 | GND | ground 3 for some sections of internal logic |
| n.c. | 97 | – | not connected |
| n.c. | 98 | – | not connected |
| n.c. | 99 | – | not connected |
| $V_{CCA2}$ | 100 | supply | isolated power supply 2 for some sections of the internal chip logic |

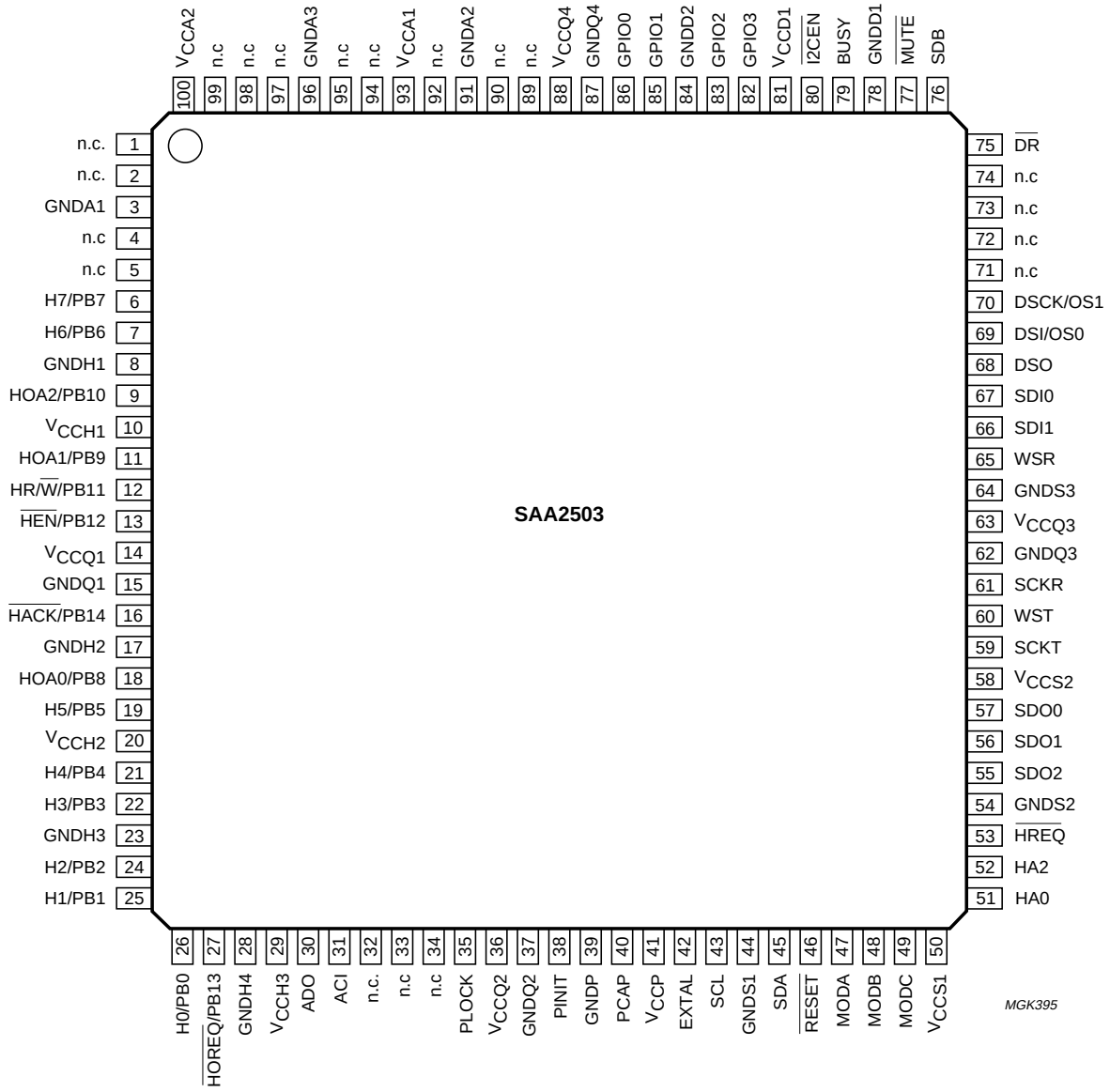



Fig.2 Pin configuration.

## FUNCTIONAL DESCRIPTION

### Operating modes

The SAA2503 can operate in 2 modes.

### Stand-alone (mode 4)

In this mode (modC = 1, modB = 0 and modA = 0) the SAA2503 boots itself from the internal program ROM after power-up and can start decoding when a decoding mode has been selected via the I²C-bus.

### Booting via the I²C-bus (mode 7)

In this mode (modC = 1, modB = 1 and modA = 1) the SAA2503 starts executing an internal boot program that will receive 1536 bytes via the I²C-bus and then write those to an on-chip program RAM.

This mode allows the standard behaviour (I/O interfaces, additional processing) to be modified as specified in the stand-alone mode.

### Decoding modes

The SAA2503 has the following decoding modes:

- MPEG decoding (48 kHz DVD; 44.1 kHz VCD) IEC 958 LPCM
- MPEG decoding (48 kHz DVD; 44.1 kHz VCD) IEC 958 BITSTR
- LPCM CD-DA (44.1 kHz)
- LPCM down-sampling DVD (96 kHz: 4 channel input; 48 kHz 2 channel output)
- LPCM DVD (48 kHz: 8 channel input; 2 channel output).

### System clock

The preferred system clock to be applied to the EXTAL pin of the SAA2503 is 27 MHz if booted in mode 4 (stand-alone operation).

The internal PLL multiplies this clock by a factor of 3 to obtain an 81 MHz internal clock.

If using another external clock frequency it is advisable to ensure that:

- The internal PLL is disabled during booting when $f_{clk(ext)} > 27$ MHz
- That 10 MHz < ($f_{clk(ext)} \times 3$) < 81 MHz.

## INTERFACING TO THE A/V SPLITTER

### Serial audio interface

The serial audio interface can be configured as an I²S-bus interface and when required, as Quad I²S interface. The signal received via the I²S-bus is an encoded audio bitstream in accordance with IEC 1937, or LPCM.

**Table 1** Pinning of the I²S-bus interface

| PINS | DESCRIPTION | PIN NUMBER | DIRECTION |
|---|---|---|---|
| SDI0 | high impedance | 67 | not used |
| SDI1 | serial data | 66 | input/output |
| SDO0 | serial data | 57 | output |
| SDO1 | serial data | 56 | not used |
| SDO2 | serial data | 55 | not used |
| SCKR | I²S-bus clock; notes 1 and 2 | 61 | input |
| WSR | word select receive | 65 | input |
| SDB | serial data begin | 76 | input |
| SCKT | I²S-bus clock; notes 1 and 2 | 59 | input |
| WST | word select transmit | 60 | input |

**Notes**

1. SCKT is equal to SCKR when the I²S-bus format is the format of the input signal. When Quad I²S-bus is used SCKT = ¼SCKR.
2. The maximum allowed clock frequency for SCK is $\frac{1}{3}f_{clk}$ ($f_{clk}$ is the internal clock generated by the PLL of the SAA2503).

### MPEG2 bitstreams

The MPEG2 audio bitstream is received via the I²S-bus in the same format as specified in IEC 1937. The MPEG2 audio bitstream consists of data bursts of 1 frame. The data is formatted in 16-bit chunks. The time period until the next frame is filled with logic 0. The serial data is received by the SAA2503 via the SDI1 pin (pin 66).

For more information on transporting MPEG2 bitstreams via IEC 958 see IEC 1937.

### Linear PCM (LPCM)

I²S-BUS

Linear PCM samples are received in an I²S-bus format. Serial audio data is received via SDI1 (pin 66). The I²S-bus clock is received via SCKR (pin 61) and the I²S-bus word select is received via WSR (pin 65); the I²S-bus clock operates at $64f_s$.

QUAD I²S-BUS

Quad I²S-bus is the interface providing audio samples in LPCM with 4 times the sampling frequency. The interface is an extension of the I²S-bus where the Serial Data Begin (SDB) indicates the first 2 channels out of 8 channels.

The audio samples are transferred with MSB first, where each sample occupies 32 bits, filled with logic 0.

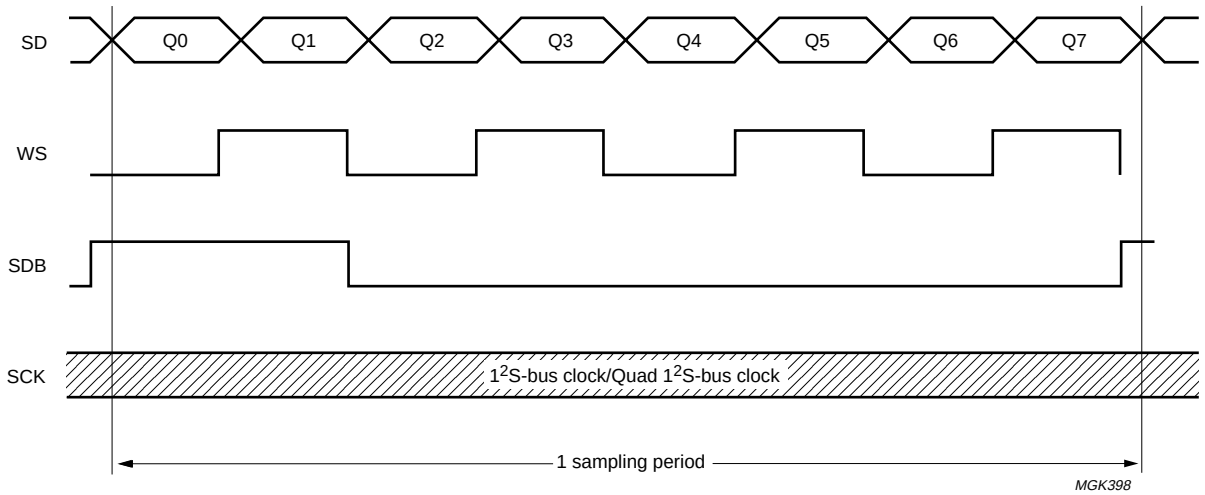



Fig.3 Quad I²S-bus frame format.

The SDB remains HIGH when only 2 channels LPCM or encode bitstreams (in accordance with IEC 1937) are transferred (Quad I²S-bus is equal to I²S-bus).

**Table 2** Allocation of LPCM channels on Quad I²S-bus, $f_s$ = 48 or 96 kHz

| NUMBER OF LPCM CHANNELS | $f_s$ (kHz) | INPUT | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | CH0 | CH1 | CH2 | CH3 | CH4 | CH5 | CH6 | CH7 |
| 1 | 48 | Q0 | mute | mute | mute | mute | mute | mute | mute |
| 2 | 48 | Q0 | Q1 | mute | mute | mute | mute | mute | mute |
| 3 | 48 | Q0 | Q1 | Q2 | mute | mute | mute | mute | mute |
| 4 | 48 | Q0 | Q1 | Q2 | Q3 | mute | mute | mute | mute |
| 5 | 48 | Q0 | Q1 | Q2 | Q3 | Q4 | mute | mute | mute |
| 6 | 48 | Q0 | Q1 | Q2 | Q3 | Q4 | Q5 | mute | mute |
| 7 | 48 | Q0 | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | mute |
| 8 | 48 | Q0 | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 |
| 1 | 96 | Q0 | mute | mute | mute | Q0 | mute | mute | mute |
| 2 | 96 | Q0 | Q1 | mute | mute | Q0 | Q1 | mute | mute |
| 3 | 96 | Q0 | Q1 | Q2 | mute | Q0 | Q1 | Q2 | mute |
| 4 | 96 | Q0 | Q1 | Q2 | Q3 | Q0 | Q1 | Q2 | Q3 |

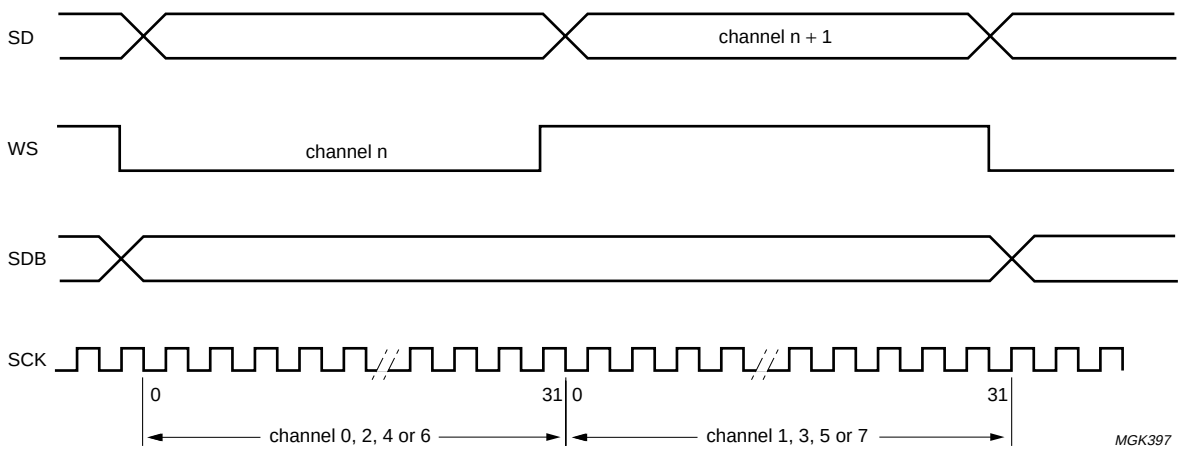



Fig.4 Quad I²S-bus channel format.

## AUDIO OUTPUTS INTERFACING

Also see Chapter “Interfacing to the A/V splitter”.

### Stereo output for DAC

The output stereo down-mixing signal is in I²S-bus format and can be directly connected to a DAC. The SDO0 (pin 57) provides the output for the serial audio data. Furthermore, SCKT (pin 59) provides the I²S-bus clock and WST (pin 60), the I²S-bus word select.

### IEC 958 transmitter

The format of the IEC 958 interface consists of a sequence of IEC 958 sub frames. Each IEC 958 sub frame is normally used to carry one LPCM sample. The IEC 958 sub frame may also be used to convey data words. The non-PCM encoded audio bitstreams to be transferred are formed into data bursts. These bitstreams consist of a sequence of data words.

Each data burst contains a 64-bit burst_preamble, followed by the burst_payload.

The burst_preamble provides a sync_word, information on the burst_payload and the bitstream number.

The interface may convey one or more bitstreams. Each type of bitstream may impose a particular requirement for the repetition time for the data bursts that make up the bitstream.

The 16-bit data words of a data burst are placed in time slots 12 to 27 of an IEC 958 sub frame. In the consumer application, both odd and even IEC 958-sub frames (CH1 and CH2) are simultaneously used to carry 32-bit data words (32-bit mode). This allows the consumer IEC 958 to convey either 2-channel LPCM audio, or a set of alternating data words, but not both simultaneously. For more information see IEC 1937.

The IEC 958 interface is of the digital audio interface. This conveys LPCM or encoded audio bitstreams according to IEC 1937 (IEC 1937), using the ‘network layer’ of IEC 958 (IEC 958). The audio data will be accompanied by a validity bit, channel status and user data (sub code).

**Table 3** Pinning of IEC 958 interface

| PINS | DESCRIPTION | PIN NUMBER | DIRECTION |
|---|---|---|---|
| ADO | Audio Data Output | 30 | output |
| ACI | Audio Clock Input; note 1 | 31 | input |

**Note**

1. The ACI clock is $256f_s$ (or 512 or $384f_s$).

## INTERFACING WITH THE MICROCONTROLLER

### Flags

The SAA2503 has 3 flags which, after a hardware reset, are all initialized to logic 1.

1. I²C-bus communication disabled (pin 80); $\overline{\text{I2CEN}}$**:** this flag is set to logic 0 when the SAA2503 is ready to accept messages via the I²C-bus.
2. Life test (pin 79); BUSY: when the SAA2503 operates in the MPEG decoding mode, this flag toggles whenever the SAA2503 has detected a synchronization pattern. The flag will then produce a 20.833 Hz ($f_{as}$ = 48 kHz) and a 19.140 Hz ($f_{as}$ = 44.1 kHz) signal. It can be used to monitor the MPEG decoding process. When this flag no longer toggles there is an error. When the SAA2503 operates in one of the LPCM modes however, the flag produces either a 23.437 Hz ($f_{as}$ = 48 kHz) or a 21.533 Hz ($f_{as}$ = 44.1 kHz) signal.
3. MPEG decoding active and synchronised (pin 77); $\overline{\text{MUTE}}$: when the SAA2503 operates in the MPEG decoding mode, this flag indicates the state of the SAA2503 (synchronized or not). When this pin is at logic 1 the SAA2503 is out of sync, when set to logic 0 the SAA2503 is synchronized. It will not change state when the SAA2503 remains synchronized. When the SAA2503 is operating in one of the LPCM modes, the $\overline{\text{MUTE}}$ pin is set at logic 1 during initialization and logic 0 during processing.

### I²C-bus interface

The I²C-bus interface supports data rates of up to 400 kbits/s. For a description of the I²C-bus see *“The I²C-bus and how to use it”*, ordering number 9398 393 40011.

For a description of the I²C-bus commands controlling the SAA2503 see Table 1.

## APPLICATION SCHEMATIC

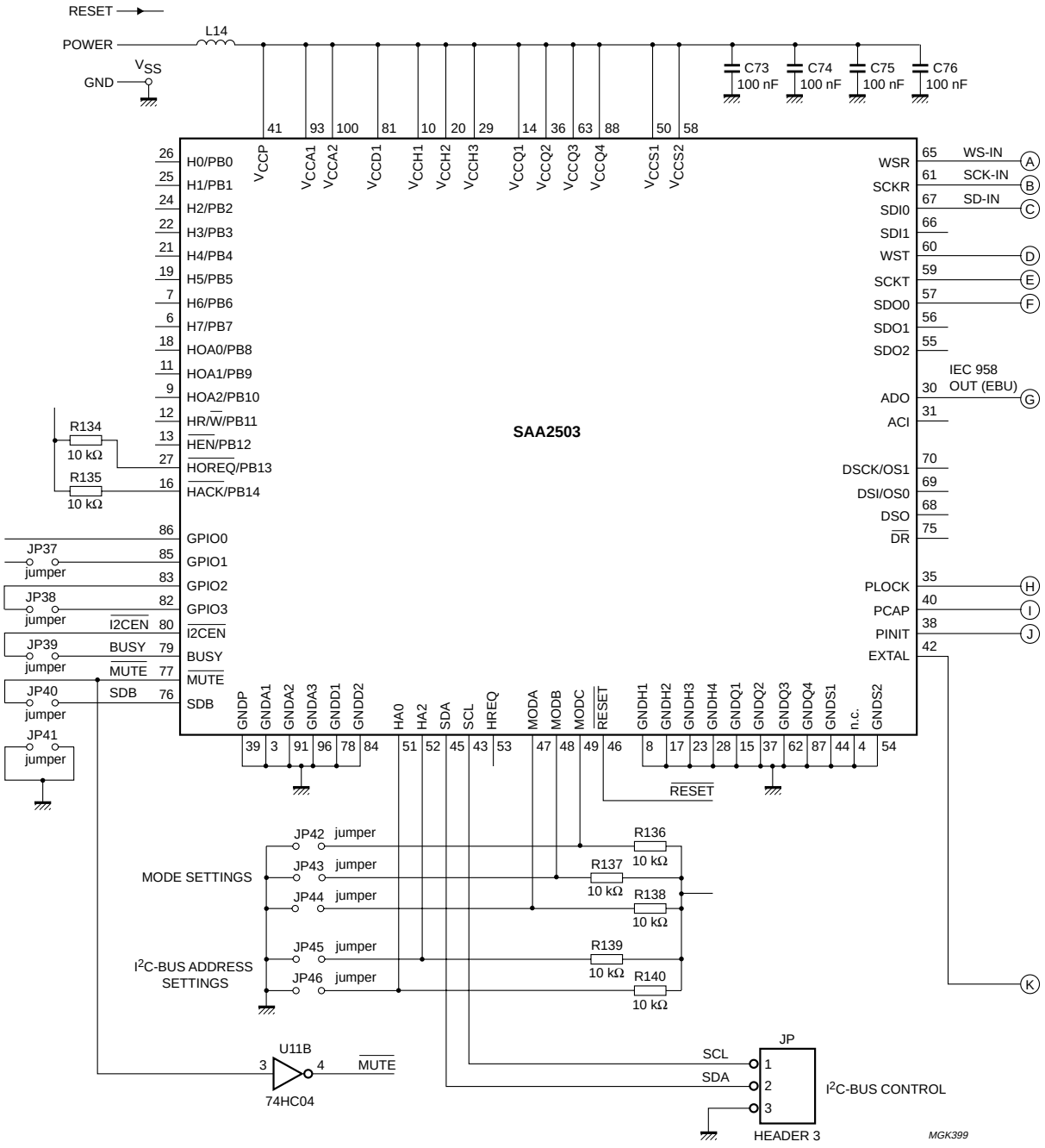



Fig.5 Application diagram (continued in Fig.6).

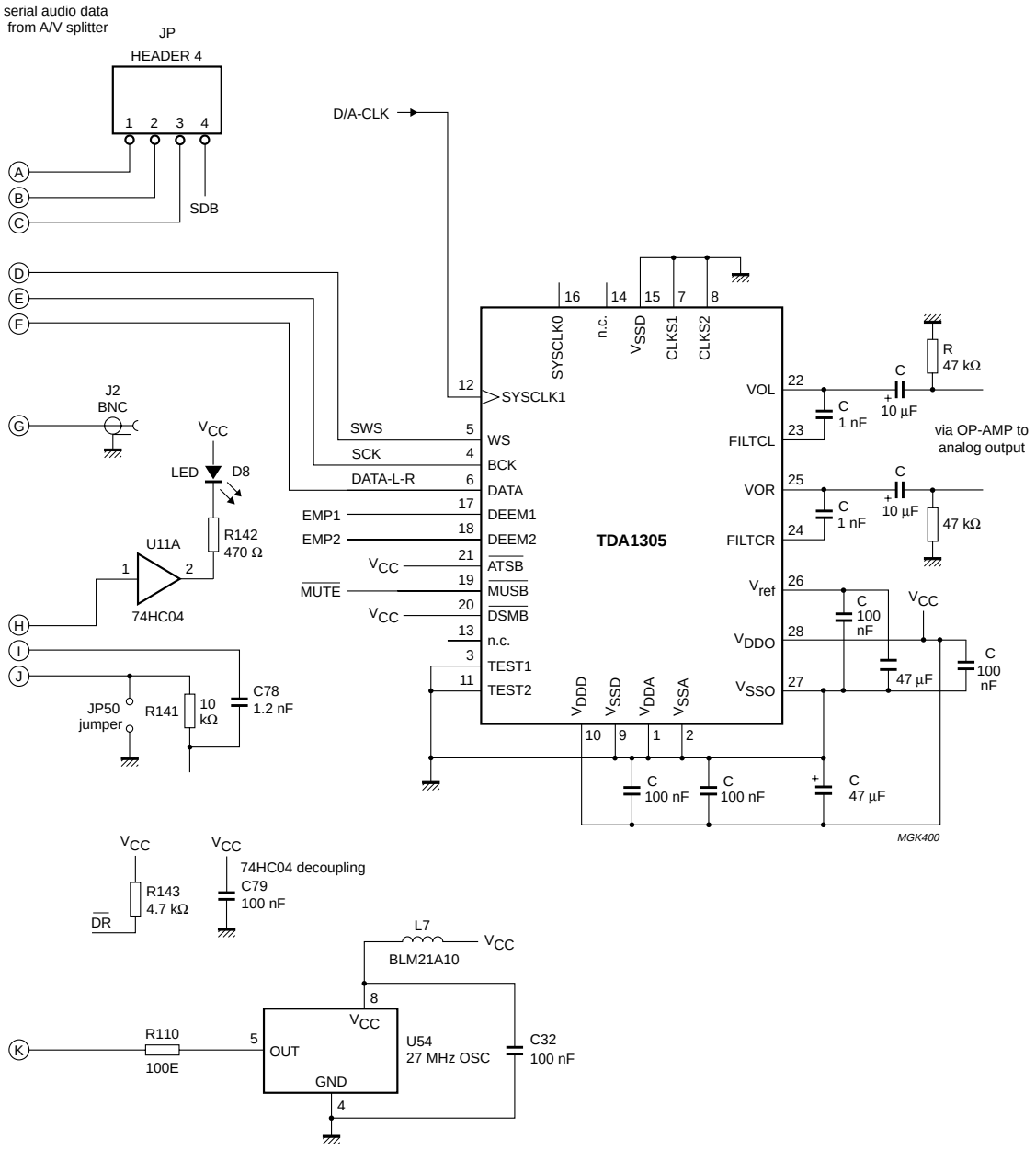
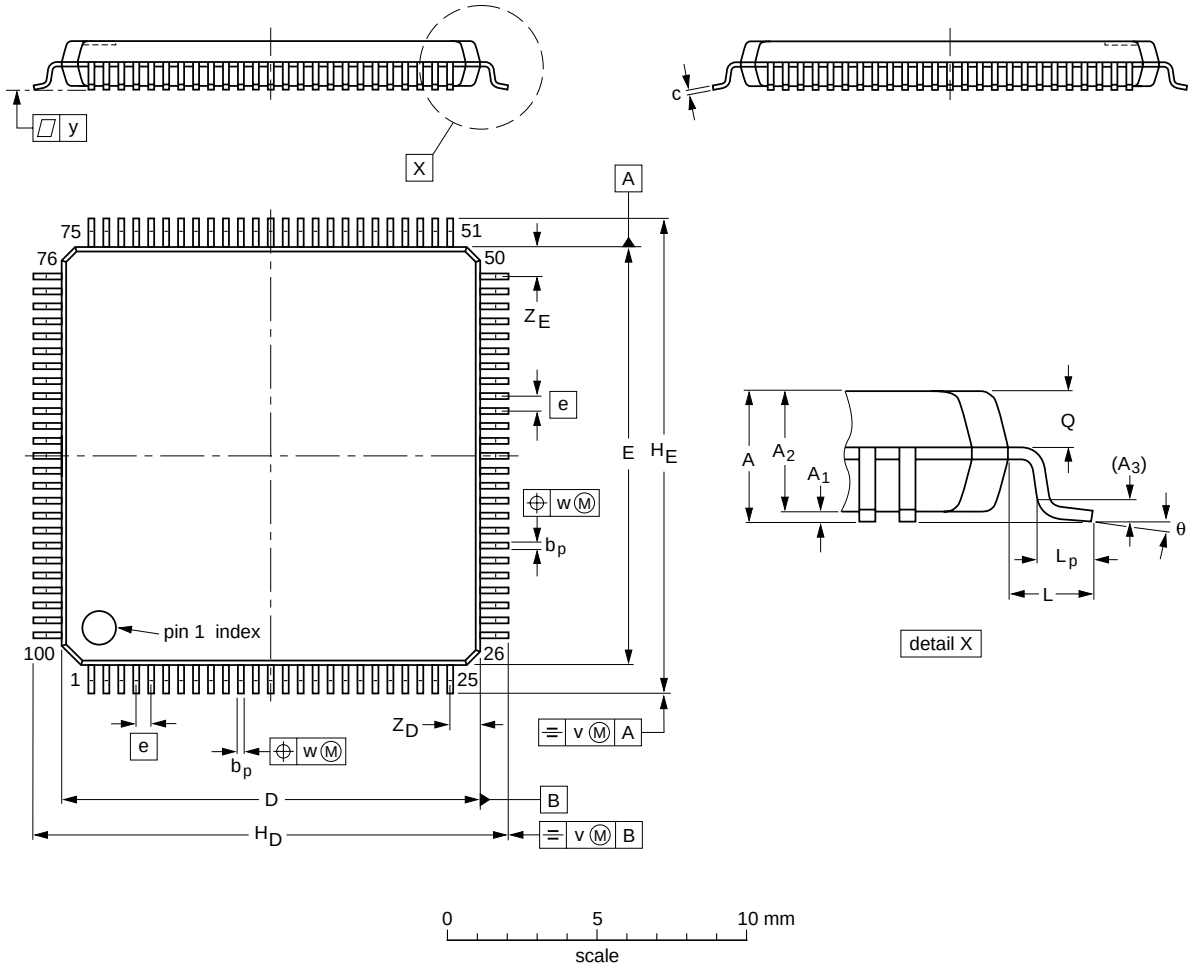



Fig.6 Application diagram (continued from Fig.5).

## PACKAGE OUTLINE

**LQFP100: plastic low profile quad flat package; 100 leads; body 14 x 14 x 1.4 mm** **SOT407-1**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A max. | $A_1$ | $A_2$ | $A_3$ | $b_p$ | c | $D^{(1)}$ | $E^{(1)}$ | e | $H_D$ | $H_E$ | L | $L_p$ | Q | v | w | y | $Z_D^{(1)}$ | $Z_E^{(1)}$ | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.6 | 0.20<br>0.05 | 1.5<br>1.3 | 0.25 | 0.28<br>0.16 | 0.18<br>0.12 | 14.1<br>13.9 | 14.1<br>13.9 | 0.5 | 16.25<br>15.75 | 16.25<br>15.75 | 1.0 | 0.75<br>0.45 | 0.70<br>0.57 | 0.2 | 0.12 | 0.1 | 1.15<br>0.85 | 1.15<br>0.85 | $7^o$<br>$0^o$ |

**Note**

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | EIAJ | | | |
| SOT407-1 | | | | | | 95-12-19 |

## SOLDERING

### Introduction

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mounted components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mounted ICs, or for printed-circuits with high population densities. In these situations reflow soldering is often used.

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"IC Package Databook"* (order code 9398 652 90011).

### Reflow soldering

Reflow soldering techniques are suitable for all LQFP packages.

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt. Dwell times vary between 50 and 300 seconds depending on heating method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 minutes at 45 °C.

### Wave soldering

Wave soldering is **not** recommended for LQFP packages. This is because of the likelihood of solder bridging due to closely-spaced leads and the possibility of incomplete solder penetration in multi-lead devices.

**If wave soldering cannot be avoided, the following conditions must be observed:**

- **A double-wave (a turbulent wave with high upward pressure followed by a smooth laminar wave) soldering technique should be used.**
- **The footprint must be at an angle of 45° to the board direction and must incorporate solder thieves downstream and at the side corners.**

**Even with these conditions, do not consider wave soldering LQFP packages LQFP48 (SOT313-2), LQFP64 (SOT314-2) or LQFP80 (SOT315-1).**

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder is 10 seconds, if cooled to less than 150 °C within 6 seconds. Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

### Repairing soldered joints

Fix the component by first soldering two diagonally-opposite end leads. Use only a low voltage soldering iron (less than 24 V) applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C. When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

## DEFINITIONS

| **Data sheet status** | |
|---|---|
| Objective specification | This data sheet contains target or goal specifications for product development. |
| Preliminary specification | This data sheet contains preliminary data; supplementary data may be published later. |
| Product specification | This data sheet contains final product specifications. |
| **Limiting values** | |
| Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability. | |
| **Application information** | |
| Where application information is given, it is advisory and does not form part of the specification. | |

## LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

## PURCHASE OF PHILIPS I²C COMPONENTS

Purchase of Philips I²C components conveys a license under the Philips' I²C patent to use the components in the I²C system provided the system conforms to the I²C specification defined by Philips. This specification can be ordered using the code 9398 393 40011.

**NOTES**

**NOTES**

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# *Philips Semiconductors – a worldwide company*


**Argentina:** see South America

**Australia:** 34 Waterloo Road, NORTH RYDE, NSW 2113,
Tel. +61 2 9805 4455, Fax. +61 2 9805 4466

**Austria:** Computerstr. 6, A-1101 WIEN, P.O. Box 213,
Tel. +43 1 60 101, Fax. +43 1 60 101 1210

**Belarus:** Hotel Minsk Business Center, Bld. 3, r. 1211, Volodarski Str. 6,
220050 MINSK, Tel. +375 172 200 733, Fax. +375 172 200 773

**Belgium:** see The Netherlands

**Brazil:** see South America

**Bulgaria:** Philips Bulgaria Ltd., Energoproject, 15th floor,
51 James Bourchier Blvd., 1407 SOFIA,
Tel. +359 2 689 211, Fax. +359 2 689 102

**Canada:** PHILIPS SEMICONDUCTORS/COMPONENTS,
Tel. +1 800 234 7381

**China/Hong Kong:** 501 Hong Kong Industrial Technology Centre,
72 Tat Chee Avenue, Kowloon Tong, HONG KONG,
Tel. +852 2319 7888, Fax. +852 2319 7700

**Colombia:** see South America

**Czech Republic:** see Austria

**Denmark:** Prags Boulevard 80, PB 1919, DK-2300 COPENHAGEN S,
Tel. +45 32 88 2636, Fax. +45 31 57 0044

**Finland:** Sinikalliontie 3, FIN-02630 ESPOO,
Tel. +358 9 615800, Fax. +358 9 61580920

**France:** 4 Rue du Port-aux-Vins, BP317, 92156 SURESNES Cedex,
Tel. +33 1 40 99 6161, Fax. +33 1 40 99 6427

**Germany:** Hammerbrookstraße 69, D-20097 HAMBURG,
Tel. +49 40 23 53 60, Fax. +49 40 23 536 300

**Greece:** No. 15, 25th March Street, GR 17778 TAVROS/ATHENS,
Tel. +30 1 4894 339/239, Fax. +30 1 4814 240

**Hungary:** see Austria

**India:** Philips INDIA Ltd, Shivsagar Estate, A Block, Dr. Annie Besant Rd.
Worli, MUMBAI 400 018, Tel. +91 22 4938 541, Fax. +91 22 4938 722

**Indonesia:** see Singapore

**Ireland:** Newstead, Clonskeagh, DUBLIN 14,
Tel. +353 1 7640 000, Fax. +353 1 7640 200

**Israel:** RAPAC Electronics, 7 Kehilat Saloniki St, PO Box 18053,
TEL AVIV 61180, Tel. +972 3 645 0444, Fax. +972 3 649 1007

**Italy:** PHILIPS SEMICONDUCTORS, Piazza IV Novembre 3,
20124 MILANO, Tel. +39 2 6752 2531, Fax. +39 2 6752 2557

**Japan:** Philips Bldg 13-37, Kohnan 2-chome, Minato-ku, TOKYO 108,
Tel. +81 3 3740 5130, Fax. +81 3 3740 5077

**Korea:** Philips House, 260-199 Itaewon-dong, Yongsan-ku, SEOUL,
Tel. +82 2 709 1412, Fax. +82 2 709 1415

**Malaysia:** No. 76 Jalan Universiti, 46200 PETALING JAYA, SELANGOR,
Tel. +60 3 750 5214, Fax. +60 3 757 4880

**Mexico:** 5900 Gateway East, Suite 200, EL PASO, TEXAS 79905,
Tel. +9-5 800 234 7381

**Middle East:** see Italy

**Netherlands:** Postbus 90050, 5600 PB EINDHOVEN, Bldg. VB,
Tel. +31 40 27 82785, Fax. +31 40 27 88399

**New Zealand:** 2 Wagener Place, C.P.O. Box 1041, AUCKLAND,
Tel. +64 9 849 4160, Fax. +64 9 849 7811

**Norway:** Box 1, Manglerud 0612, OSLO,
Tel. +47 22 74 8000, Fax. +47 22 74 8341

**Philippines:** Philips Semiconductors Philippines Inc.,
106 Valero St. Salcedo Village, P.O. Box 2108 MCC, MAKATI,
Metro MANILA, Tel. +63 2 816 6380, Fax. +63 2 817 3474

**Poland:** Ul. Lukiska 10, PL 04-123 WARSZAWA,
Tel. +48 22 612 2831, Fax. +48 22 612 2327

**Portugal:** see Spain

**Romania:** see Italy

**Russia:** Philips Russia, Ul. Usatcheva 35A, 119048 MOSCOW,
Tel. +7 095 755 6918, Fax. +7 095 755 6919

**Singapore:** Lorong 1, Toa Payoh, SINGAPORE 1231,
Tel. +65 350 2538, Fax. +65 251 6500

**Slovakia:** see Austria

**Slovenia:** see Italy

**South Africa:** S.A. PHILIPS Pty Ltd., 195-215 Main Road Martindale,
2092 JOHANNESBURG, P.O. Box 7430 Johannesburg 2000,
Tel. +27 11 470 5911, Fax. +27 11 470 5494

**South America:** Rua do Rocio 220, 5th floor, Suite 51,
04552-903 São Paulo, SÃO PAULO - SP, Brazil,
Tel. +55 11 821 2333, Fax. +55 11 829 1849

**Spain:** Balmes 22, 08007 BARCELONA,
Tel. +34 3 301 6312, Fax. +34 3 301 4107

**Sweden:** Kottbygatan 7, Akalla, S-16485 STOCKHOLM,
Tel. +46 8 632 2000, Fax. +46 8 632 2745

**Switzerland:** Allmendstrasse 140, CH-8027 ZÜRICH,
Tel. +41 1 488 2686, Fax. +41 1 481 7730

**Taiwan:** Philips Semiconductors, 6F, No. 96, Chien Kuo N. Rd., Sec. 1,
TAIPEI, Taiwan Tel. +886 2 2134 2865, Fax. +886 2 2134 2874

**Thailand:** PHILIPS ELECTRONICS (THAILAND) Ltd.,
209/2 Sanpavuth-Bangna Road Prakanong, BANGKOK 10260,
Tel. +66 2 745 4090, Fax. +66 2 398 0793

**Turkey:** Talatpasa Cad. No. 5, 80640 GÜLTEPE/ISTANBUL,
Tel. +90 212 279 2770, Fax. +90 212 282 6707

**Ukraine**: PHILIPS UKRAINE, 4 Patrice Lumumba str., Building B, Floor 7,
252042 KIEV, Tel. +380 44 264 2776, Fax. +380 44 268 0461

**United Kingdom:** Philips Semiconductors Ltd., 276 Bath Road, Hayes,
MIDDLESEX UB3 5BX, Tel. +44 181 730 5000, Fax. +44 181 754 8421

**United States:** 811 East Arques Avenue, SUNNYVALE, CA 94088-3409,
Tel. +1 800 234 7381

**Uruguay:** see South America

**Vietnam:** see Singapore

**Yugoslavia:** PHILIPS, Trg N. Pasica 5/v, 11000 BEOGRAD,
Tel. +381 11 625 344, Fax.+381 11 635 777

**For all other countries apply to:** Philips Semiconductors, Marketing & Sales Communications,
Building BE-p, P.O. Box 218, 5600 MD EINDHOVEN, The Netherlands, Fax. +31 40 27 24825

**Internet:** http://www.semiconductors.philips.com



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